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SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE
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FOR THE ADVANCEMENT OF SCIENCE.

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FRIDAY, JUNE 27, 1902.

THE UNIVERSITIES IN RELATION TO RESEARCH.*

It is now many years since I came to the conclusion that the provision of adequate facilities for research is one of the prime necessities of university education in Canada; and it is with the object of accelerating the movement which has already begun in this direction that I have selected the relation of the universities to research as the topic of my remarks on this occasion.

It will perhaps be expedient for me at the outset to say that I propose to use the word research in its widest meaning, *i. e.*, as indicating those efforts of the human mind which result in the extension of knowledge, whether such efforts are exerted in the field of literature, of science or of art. It is a common mistake to apply the term research to what we somewhat erroneously denominate as 'science,' meaning thereby the physical and natural sciences. This limitation is comparatively modern, and science so defined is after all only a part of human knowledge.

The limits of research in its wider sense are coterminous with the knowable, and research itself is of very ancient date. The fund of knowledge accumulated even before the Christian era was enormous. This great fund, however, remained stationary,

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N.Y.

* Address of the President of the Royal Society of Canada at the Toronto Meeting, May 27, 1902.

or nearly so, throughout the Dark and Middle Ages. During this period of mental stagnation, authority was the watchword of the learned. All knowledge was supposed to have been already discovered, and the efforts of the schoolmen were devoted to the application of this body of truth to life and conduct. This mediaeval point of view has been quaintly and aptly put by Chaucer:

Out of olde feldies, as man saith,
Comith all this newe corne from yere to yearn;
And out of olde bokis, in good faithe,
Comith all this newe science that menne learn.

With the Renaissance began a new epoch, an epoch in the midst of which we are still living. It marked, as has been well said, 'the liberation of the reason from a dungeon, the double discovery of the outer and inner world.' The study of the humanities, which was an incident of the Renaissance, rendered available to modern men the wisdom of the ancients. But much of the old knowledge was found to be spurious when examined with the new light, and even the authority of Aristotle, the demigod of the scholastics, was discredited. Nothing henceforth was to be accepted on trust, and the injunction to 'prove all things' became the watchword of the learned.

Although the Renaissance marked the regeneration of philosophy, of criticism, and in general of the whole process of thought, it especially denoted the birth of the physical and natural sciences, and hence their rise and progress may be taken as best illustrating the working of the new spirit of research. Roger Bacon in the thirteenth century protested vainly against the despotism of Aristotle, and advocated a new and fruitful learning which should be based upon experience. In the two centuries which followed, those scholars described by Whewell as the 'Practical Reformers,' working in their primitive

laboratories, established a sound basis for a future natural philosophy. One of these, Leonardo da Vinci (1452-1519), both a practical and a theoretical philosopher, anticipated modern science in his remark: "The interpreter of the artifices of nature is experience, who is never deceived. We must begin from experiment and try to discover the reason." Telesio (1508-1588), called by Francis Bacon 'primus hominum novorum,' said: "The construction of the world and the magnitude and nature of the bodies in it are not to be investigated by reasoning, as was done by the ancients; but they are to be apprehended by the sense and collected from the things themselves." These were some, but not nearly all, of the forerunners of Francis Bacon (1561-1626) who by his writings, and especially by his 'Novum Organum,' elaborated in detail a method of research, the principles of which had been laid down by his predecessors.

From the overturning of the authority of Aristotle and the laying down of a secure basis for the advancement of knowledge, it was but a step to the inauguration of organized research, the aspect of the question to which I wish to invite your attention somewhat more in detail.

The chief agencies of modern organized research are (1) the learned societies and (2) the universities. The former receive and publish research papers; the latter superintend and direct investigators and publish results. To these should properly be added the various journals which have been established and carried on by private effort. It is a significant fact that the establishment of modern learned societies coincides closely in time with the Renaissance movement. Telesio, mentioned above, established one of the earliest mathematico-physical societies—the Academy of Cosenza. Other Italian societies of similar scope were founded in Rome in 1603, in

Florence in 1657, and the Royal Society of London dates from 1660 or earlier. Organized research in universities was of slower growth. In them the mediæval spirit was tenacious of life, and it was only in the nineteenth century, in Germany, at the close of the Napoleonic wars, that research, not only in natural philosophy, but in the whole field of knowledge, became the basis of the German educational system, and I might remark, without going into details, that the university systems of France and the other principal countries of Europe, with the exception of Great Britain, are in the main parallel with that of Germany, although not so consistently elaborated. To understand then what organized university research means in the fullest development which it has hitherto attained, let us turn our attention a little to Germany, of the educational system of which it forms an essential part.

We are so subject to the authority of words that it is difficult for us to realize that the organization called a university in Germany is almost entirely different in scope and object from the institution which we so designate in this country. Hitherto, at least in England and Canada, the function of the university has mainly been to impart a general and liberal education, continuing and completing the beginning already made in the secondary school. Speaking generally, I may say that under the German system the work of our secondary schools and universities combined is performed by the gymnasium, the nine or ten years' training of which leaves the young man of nineteen or twenty years of age with a much better liberal education than that possessed by the average graduate in arts of an English, Canadian or American university. How this is accomplished it is not my purpose here to explain. There is no doubt, however, as to the fact, which is substantiated both by the

nature of the curriculum of the gymnasium and by the testimony of those familiar with both systems. In this connection I recall the observation made to me on one occasion by a professor here, himself a wrangler of high standing in Cambridge, who remarked that it was always a mystery to him how the German gymnasiums attained such extraordinary results, results which, he added, it would be hopeless to expect in England, while on the other hand I have more than once heard German professors express surprise at the meager equipment of university graduates from America.

It is upon this substantial preliminary training that the work of the German university proper is based. Up to this point the young man has been a 'learner'; on entering the university he becomes a 'student.' This distinction, expressed by the German words 'lernen' and 'studieren,' marks the difference between gymnasium and university—the acquisition of knowledge under the teacher in one, the independent research under the guidance of the professor in the other.

The typical German university possesses the four faculties of theology, law, medicine and philosophy. The scope of the first three is evident from their designation, and with them we are not at present immediately concerned. The faculty of philosophy embraces the subjects which we include as university studies, under the head of arts and science. It is the most important of the four, the professors in it sometimes outnumbering those of all other faculties combined. The ultimate object of both professors and students is the advancement of knowledge and the independence with which research is conducted is well expressed by the two words 'Lehrfreiheit' and 'Lernfreiheit'—the freedom of the professor as to what he teaches and the freedom of the student to select his special line of research. Some idea of the

extent of this work may be formed from the number of universities in Germany, 21 in all, and from the fact that the aggregate number of matriculated students exceeds 12,000, in addition to non-matriculated students, who are also numbered by thousands, while the philosophical faculty at Berlin and Leipzig in 1901-2 numbered, respectively, 207 and 120. To the 21 universities mentioned should be added the nine *technische Hochschulen* which have now the right to confer the doctor's degree in the applied sciences.

It is impossible to exaggerate the enthusiasm which prevails among both professors and students in their common object, and this enthusiasm is increased by legitimate emulation. The reputation of a university depends upon the progress made by its professors, the reputation of a professor upon the progress made in his department. Hence a student may be attracted from one university to another—which is allowable under the system—may choose to follow the lectures of the professor, ordinary or extraordinary, or even those of the *privat-docent* in his own particular line of work. Under such a system and under such stimulating conditions it is evident that both professors and students must take their work seriously, with the result that the combined effort of a vast number of the best minds in the country is concentrated on the advancement of all the principal branches of knowledge. With regard to the research work done by the student and without which the degree of Ph.D. is not conferred, it may be objected that much of it is not important and sometimes very trivial. It may be said, however, that it must all stand the test of publication after being approved by the professor, so that its value may at once be estimated by the learned world, and the scholastic standing of professor and student rated accordingly.

The place and importance of research in the German system is further indicated by the fact that even teachers in the gymnasium devote themselves to such work, their papers being published in the annual reports of their institutions. With such respect is the ability for research regarded that the publication of a paper of this kind may lead directly to a professorship in the university, as was the case, for instance, in the appointment of Weierstrass, the celebrated mathematician.

Let us now turn our attention for a few moments to the British university system. An extended description is unnecessary, since we are all familiar with the working of British universities themselves, or with the Canadian or American development of the original British type. Hence it may suffice if I contrast briefly the British and German systems in some of their essential features.

In the organization of the German university research has been shown to be a fundamental principle; in the British university it is as yet incidental or of sporadic manifestation. I do not of course ignore the very important contributions which have been made by British scholars to the advancement of learning, but it is worthy of note that the credit for their splendid achievements is rather due to the individuals themselves than to the universities with which many of them were connected. The British university is not primarily an institution for research. In its function of providing the higher grades of a liberal education the proper comparison is with the upper classes of the German gymnasium, not with the German university proper. True, we find in some of the British universities a specialization in certain subjects, *e. g.*, in honor classics and mathematics at Oxford and Cambridge leading to higher work than that attempted in the gymnasium; but however advanced

the studies may be, there is rarely any attempt to guide the English undergraduate in the direction of research. Reading and examinations are the academic watchwords, and to the great mass of students and tutors the field of research is a *terra incognita*.

The attitude of the British nation has been hitherto largely that of indifference towards organized research, and this has been true not only of the general public, but also of those engaged in academic administration. There has existed a deep-seated conviction, born perhaps of reiterated assertion, that the British university system is superior to that of Germany or any other country, and as near perfection as may well be. We are not concerned just here with the discussion of the merits of the system, which are undoubtedly many and great, but we must admit that the attitude of self-satisfaction which has prevailed, combined with the ignoring of other ideals, is at least unphilosophic. In the midst of such an atmosphere it is not surprising that the development of a true Renaissance spirit has been somewhat tardy.

But the British nation is on the eve of an awakening, an awakening which has already taken place among certain leaders of thought. The fact is dawning upon the British mind that some vital connection really does exist between national progress and scientific discovery, and that the latter should be fostered in connection with the higher institutions of learning. Under the conviction that British commercial supremacy will be seriously threatened unless foreign, and especially German, scientific methods are adopted, universities of more modern type than Oxford and Cambridge, and also technical colleges, have been established. Such institutions no doubt fill a long-felt want, but they do not go to the root of the matter. On the academic side

they are but a modification of the older type; on the technical side they contemplate, not the discovery of new truth, but the application of what is already known. The spirit of research is lacking, and without it no expenditure of money, no raising of examination standards for mere acquirement, will actually increase the capital account of national knowledge.

It is perhaps owing in part to the general awakening already mentioned that a rudimentary scheme of research has been recently introduced in the University of Cambridge, where students pursuing original investigations are placed on the same level as the ordinary undergraduate and may obtain the B.A. degree as a reward for work of this kind. Notwithstanding the lack of more substantial encouragement a number of students have entered these courses, being attracted by the reputation of certain professors who are themselves zealously engaged in the prosecution of research. The number of such students, however, is relatively small, nor can it be said that the movement has become general, although other universities are beginning to do something in this direction, but it may perhaps prove to be the germ of a more complete organization in the future.

The policy of the universities of the United States regarding this matter is in marked contrast with the indecision and conservatism which prevail in the mother country. The type of mind which has been developed in the century and a quarter of separate national existence is one of great vigor and originality; but these qualities have for the most part been turned aside by the circumstances of a new country from abstract investigations. Research after the almighty dollar by the nearest short-cut has been, and perhaps still is, regarded as the chief national characteristic of our American cousins, and in this pursuit they have displayed a genius

for concrete research in mechanical invention and an ability for commercial and industrial enterprise which have been an object of wonder, and latterly of anxiety to other nations. During the first hundred years of national existence the university of the gymnasium type which has been inherited from England continued to develop and expand in the United States. Suddenly, however, almost exactly twenty-five years ago, a remarkable modification was introduced. The year 1877 marks an epoch in the establishment of the Johns Hopkins University, with research courses leading to the degree of Ph.D. as an addition to the usual undergraduate work; in other words, a grafting of the German university system upon the original stock. It is proper to state that even before that date research work had been prosecuted incidentally in some of the older existing universities. On consideration of the circumstances it is not difficult to account for this new departure. The movement was undoubtedly due to the influence of American students who had gone to Germany for special studies. This migration to and fro had been going on for some time before the founding of Johns Hopkins and still continues, the number of such students gradually increasing from 77 in 1860 to an average of about 400 annually during the last decade. The new university experiment was a success from the first. The scheme was carried out on such a high plane that large numbers of able and zealous students were attracted from all parts of the continent by the facilities for higher study and by the scholarships and fellowships which formed part of the scheme. The appointment of graduates of Johns Hopkins to positions in other universities and their success as teachers and investigators have led to a widespread demand for professors who have proved their capacity for original work.

Since 1877 many other universities, including the best of those already in operation, as well as new foundations, have added a graduate department leading to the Ph.D. degree, although none of these, with the exception of Clark University, has made the prosecution of research the sole business of the university. Some idea of the rapid progress of this movement may be gathered from the fact that the numbers pursuing graduate studies in the universities of the United States have increased from eight, in 1850, to 399 in 1875, and to about 6,000 in 1902. We must conclude from these figures, I think, either that the national mind discerns some ultimate advantage in the cultivation of abstract science, or that, for once, it has been mysteriously diverted from the pursuit of the 'main chance.' It is surely significant that a practical philanthropist like Mr. Carnegie has recently bestowed the magnificent endowment of \$10,000,000 for the establishment of an institution to be devoted solely to the promotion of research.

As to the ultimate scientific value of what has already been accomplished in the way of research under the influence of this recent movement, there is room for a qualifying remark. It must be remembered that much of the graduate work referred to does not mean actual research, the course for the Ph.D. in many cases being no higher than the honor B.A. course with us. What is required to remedy this unsatisfactory condition is that the Ph.D. be given only on the German plan, and that the main test therefor, a research, be published. When this condition becomes absolute there will be material for the world's judgment as to the amount and quality of the contribution to the advancement of knowledge.

Organized research in Canadian universities, as a definite system, can scarcely be said to exist as yet, although within the

last decade certain beginnings have been made which indicate a movement in that direction. Canada, like the United States, has derived its university ideals from Great Britain. Some of the original faculties of our universities were a transplantation, so to speak, of groups of scholars from Britain, who brought with them intact the traditions in which they themselves had been nurtured, so that we received by direct importation scarcely more than fifty years ago a system which in the United States had been developing in its own way since the founding of Harvard in 1636. I cannot better illustrate the attitude towards research of many of these academic pioneers than by quoting the remark made by an English professor—himself a classical scholar—on an occasion so comparatively recent as the establishment of the physical laboratory in the University of Toronto. 'Why go to the expense,' said he 'of purchasing this elaborate equipment until the physicists have made an end of making discoveries?'

In the interval the idea of research has made gratifying progress among the well-informed. Probably few scholars could now be found in Canada who would put their objections so naïvely as my classical friend. This progress has come in part from a natural process of evolution within ourselves, and in part also from external influences, notably that of Germany and the United States. Many of our graduates have pursued courses of study in Germany and have brought back with them the German ideal. Besides, such is the geographical position of Canada with regard to the United States, and such the community of social and intellectual life, that the universities of these two countries must inevitably develop along parallel lines; and hence, if for no other reason, we may look forward to the gradual extension here of

the research movement which is already so widespread in the neighboring republic.

That a natural and healthy demand for this kind of work already exists may, I think, be inferred from the success which has attached to the recent establishment of the doctorate degrees in certain universities, but still more perhaps from the fact that for some years it has been customary in some cases to direct honor students in the final year of the B.A. course to the work of research. In illustration of what has been accomplished in this way I may state that some of the papers presented in Section III. at the present meeting have been prepared by undergraduates in arts in the University of Toronto. But whatever may be the ultimate outcome of the research movement with us, permit me to repeat what I have already said in another connection, namely, that the Ph.D. should not be given without the presentation of a satisfactory thesis, and that such research should be published before the degree is awarded.

I have confined my remarks up to this point almost wholly to the historical aspect of the question, but it will perhaps not be out of place for me to point out in conclusion some of the advantages which in my opinion are connected with the pursuit of university research.

Let us consider first the stimulating effect upon the individuals and institutions concerned. Among those who are affected by this stimulus should first be named the professor. Dr. Samuel Johnson was wont to compare accumulated knowledge to a heap of ice lying exposed to the summer sun, the bulk of which could not be maintained without constant replenishment. Continuing the figure, we can readily imagine that the professor's fund of knowledge which is ample enough for the classroom teaching of immature minds might

shrink and trickle away until little is left but the sawdust which we usually associate with the preservation of that commodity. Under the stimulus of research this is impossible, for research into the new implies a full and minute mastery of that branch of knowledge in which the research is being conducted. Hence if no other advantage resulted a good case might be made out along this line of argument.

This stimulus to the professor would react with increased force upon the student. It was a favorite saying of a certain celebrated artist that those who follow after others rarely outstrip them. To hold up before the student either by theory or practice solely the ideal of acquiring what has already been learned is mediævalism pure and simple; it is to teach him to creep where he might walk upright and alone; it is to rob him in part of that intellectual birthright of independent thought which is the inheritance of every man, at least since the Renaissance. It is sometimes objected that the results attained by research students are often trivial or futile. I am disposed, however, to agree with a remark made by one of George Eliot's characters: "Failure after long perseverance is much grander (and I would say parenthetically more useful) than never to have a striving good enough to be called a failure." It is sometimes also urged that research in the immature student leads to superficiality and conceit. I cannot but think this fear ill-grounded. It has been proved on the contrary that nothing will so quickly ripen and enlarge preliminary knowledge and so effectually extinguish presumption as the hand-to-hand struggle with some special problem in the department of study in which the student is already proficient.

Apart from the professor and student, the first effect of the inauguration of re-

search work in our universities, if of the genuine stamp, will be felt upon the teaching profession of the country as a whole. Assuming an educated and interested public opinion, the premium so long placed upon memorized knowledge will disappear, and a change in the principle of selection of teachers both in universities and secondary schools will result. The time will have gone by, let us hope, when Huxley will be passed over, as was the case fifty years ago, when his candidature for a chair in the Provincial University was unsuccessful.

We come finally to the effect of research upon the national life. Canada, it is true, is barely on the threshold of national existence, rich, however, in natural resources, and richer still in the physical, moral and intellectual qualities of its people. Its future as a nation will depend largely upon the aggregate of intellectual effort of its population. In this sense truly knowledge is power. The time has surely come when we should cease to take all our knowledge at second hand from abroad, and when we should do some original thinking suitable to our own circumstances. Under the term original thinking I do not include merely the researches of the laboratory, for the spirit of research which inspires the chemist or the philologist is one with that creative faculty which moves the poet and the novelist, a spirit which guides all contemporary movements in literature, science and art. For the development of this spirit of originality the country must look primarily to its universities, for on them depends ultimately the whole intellectual life of the people. The time is approaching, if indeed it has not already arrived, when the research university must be regarded as the only university, and the task is incumbent upon those in authority of elaborating a university system not necessarily in imitation of those of other lands, but one which shall have proper regard to the

importance of this new factor as well as to the past and future of our country.

JAMES LOUDON.

UNIVERSITY OF TORONTO.

SECTION OF THE GEOLOGICAL AND BIOLOGICAL SCIENCES.

THE meeting of the Royal Society of Canada at Toronto, May 26-29, was one of great interest, especially so in regard to the value and importance of the papers and discussions in Sections 3 and 4, whose particular province is the study of the natural and applied sciences. The meetings were held within the precincts of the University of Toronto, whose ample halls and well-equipped laboratories were placed freely at the disposal of the Society. The beautiful 'Queen City' of Canada was bright with blossoms and the fresh-tinted foliage of the trees which so abundantly adorn her broad avenues. A generous welcome was extended by her citizens to the fellows and delegates of the Society who represented Canada from Halifax to Winnipeg. The meeting lacked the genial presence and active inspiration of Sir John Bourinot, the honorary Secretary, whose serious illness was a matter of deep regret to all. His rare executive ability and tact, and the control which he has so wisely exercised in guiding the Society during the twenty perilous years of its existence, are shown in the position which it occupies to-day. The stimulus which it has given to original research and the world-wide interest which the publication of its proceedings has awakened have been in a large measure due to his fostering care and unremitting industry.

Among the recommendations contained in the report of the honorary Secretary were the following: That everything possible should be done to preserve historical sites in Canada; that systematic ethnological work should be carried on; that the

Canadian people should cooperate with the people of the United States and Mexico in determining the ninety-eighth meridian; and that the operations of the Government Marine Station of Biology should be continued and increased. During the meeting committees considered several of these recommendations and emphasized their importance in subsequent reports.

The address of the president, Dr. Loudon, of Toronto University, on 'Research in Universities,' was a careful presentation of the subject, showing what has been done—and what has not been done—in German, English, United States and Canadian Universities.

In Section 4 a large proportion of the papers read embraced topics on the geology of various sections of eastern Canada. One of the most important of these was a paper on the sites of ancient volcanic activity in the neighborhood of the St. Lawrence Valley, by Professor Frank D. Adams, of McGill University. After an introductory reference to the recent outbreak on the island of Martinique, Dr. Adams gave an account of the general geological structure and petrographical character of the series of ancient volcanic hills which rise from the Paleozoic plain to the east of Montreal. These are eight in number and are arranged along two parallel and almost straight lines, evidently ancient lines of weakness. Those situated on the most northerly of these lines, commencing from Mount Royal on the west and going east, are Mount Royal, Montarville, Belceil, Rougemont, Yamaska and Shefford. The distance from Mount Royal to Shefford Mountain is fifty miles. The mountains on the southern line are two in number—Brome Mountain and Mount Johnson. Of these hills Mount Royal (Mons Regius), at the foot of which the city of Montreal is situated, is the best known and may be taken as the type of the series. Dr. Adams proposes for the group